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ATMOSPHERIC RESPONSE TO GEOMAGNETIC ACTIVITY.(U)
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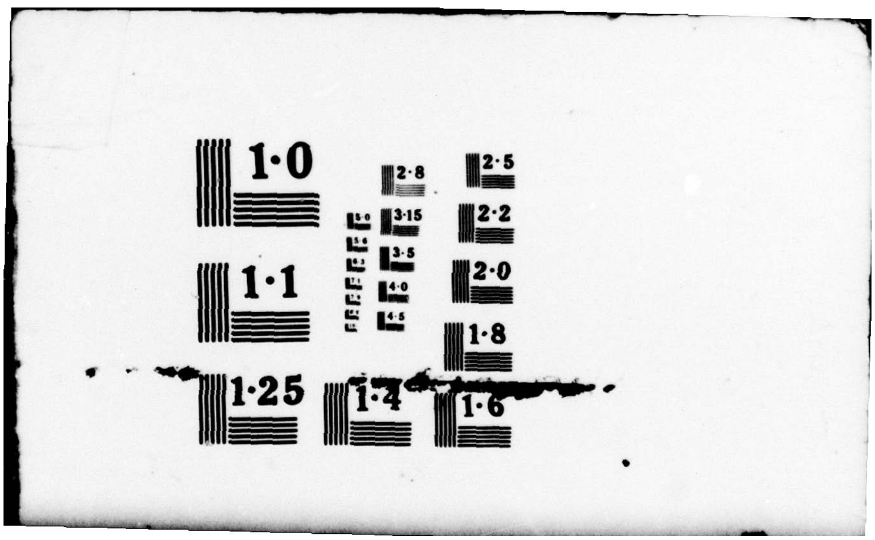
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REPORT DOCUMENTATION PAGE — READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: (14) AFGL-TR-79-0090
2. GOVT ACCESSION NO.:
3. RECIPIENT'S CATALOG NUMBER:
4. TITLE (and Subtitle): (6) ATMOSPHERIC RESPONSE TO GEOMAGNETIC ACTIVITY.
5. TYPE OF REPORT & PERIOD COVERED: ~~Scientific.~~ (9) Interim rept.,
6. PERFORMING ORG. REPORT NUMBER:
7. AUTHOR(s): (10) F. A. Marcos
8. CONTRACT OR GRANT NUMBER(s):
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Air Force Geophysics Laboratory (LKB), Hanscom AFB, Massachusetts 01731
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: ~~62101F~~ (16) 66900403 (17) 04
11. CONTROLLING OFFICE NAME AND ADDRESS: Air Force Geophysics Laboratory (LKB), Hanscom AFB, Massachusetts 01731
12. REPORT DATE: (11) 12 April 1979
13. NUMBER OF PAGES: 8
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): (12) 10p.
15. SECURITY CLASS. (of this report): Unclassified
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE:
16. DISTRIBUTION STATEMENT (of this Report): Approved for public release; distribution unlimited.
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report):
18. SUPPLEMENTARY NOTES: Reprinted from the Proceedings of Symposium on Scientific Results of Atmosphere Explorer, held October 27-29, 1976, at Bryce Resort Inn, Basye, VA, Volume 2
19. KEY WORDS (Continue on reverse side if necessary and identify by block number):
Satellite
Accelerometers
Atmospheric density
Atmospheric storms
Geomagnetic activity
20. ABSTRACT (Continue on reverse side if necessary and identify by block number):

Atmospheric density and composition have been measured by experiments on two low altitude satellites during the same time period. The instruments were on the NASA Atmosphere Explorer-C (AE-C) and Air Force S3-1 satellites respectively. Results have been correlated for the period of 8-15 Nov 74 when AE-C was in the southern hemisphere and S3-1 was in the northern hemisphere. This report examines the spatial and temporal response of the atmosphere to two large geomagnetic storms with maximum Kp values of 6+ and 7 respectively. Results are presented at 160 km for

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each satellite. Density and composition variations observed during the storms show significant differences from atmospheric behavior predicted by current models. These differences occur in both the magnitude and phase of the measured atmospheric response. Important localized enhancements are also found at high latitudes, indicative of direct heating of this region.

AFGL-TR-79-0090

ATMOSPHERIC RESPONSE TO GEOMAGNETIC ACTIVITY

F. A. Marcos

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Abstract. Atmospheric density and composition have been measured by experiments on two low altitude satellites during the same time period. The instruments were on the NASA Atmosphere Explorer-C (AE-C) and Air Force S3-1 satellites respectively. Results have been correlated for the period of 8-15 Nov. 74 when AE-C was in the southern hemisphere and S3-1 was in the northern hemisphere. This report examines the spatial and temporal response of the atmosphere to two large geomagnetic storms with maximum Kp values of 6+ and 7 respectively. Results are presented at 160 km for each satellite. Density and composition variations observed during the storms show significant differences from atmospheric behavior predicted by current models. These differences occur in both the magnitude and phase of the measured atmospheric response. Important localized enhancements are also found at high latitudes, indicative of direct heating of this region.

Recent *in situ* measurements of neutral composition and total density from Ogo 6 and Esro 4 have established that the atmosphere responds in a complex and variable pattern of behavior to magnetic storms. A more pronounced perturbation is observed at high latitudes where large amounts of energy are deposited during storms by processes related to ionospheric currents and particle precipitation. Heating, convection and circulation contribute to the observed atmospheric variability. While most of the satellite data have been obtained at altitudes above 250 km, the results indicate that the heat input occurs well below 200 km.

One of the types of studies utilizing AE data involves correlation of data with results from other satellites in orbit at the same time. The long lifetime of AE-C provides many opportunities for such comparisons. This report describes a study relating AE-C density and composition measurements in the southern hemisphere with similar data from the Air Force S3-1 low altitude satellite in the northern hemisphere. Neutral atmospheric density measurements were obtained from the accelerometer experiments on AE-C and S3-1 (Champion and Marcos, 1973). Composition data were obtained from the AE-C OSS experiment (Nier et al., 1973) and the S3-1 mass spectrometer experiment (Philbrick et al., 1976). Comparisons are made at 160 km altitude where there has been a paucity of data.

In this study the variations in neutral density related to the geomagnetic activity during the period 11-15 Nov. 74 are first examined. This allows elucidation of some general storm-related atmospheric features. The study is then expanded to include both density and composition variation for the period 8-15 Nov. 74.

Figure 1 compares the accelerometer density results obtained from both satellites at 160 km altitude. The time period covered is 11-15 Nov. 1974 (days 315-319). The top part of the figure gives measured density values; the middle part gives the ratio of measured density to the Jacchia (1971) model and the bottom part shows the Kp index. Asterisks represent AE-C data and squares represent S3-1 data. Latitude of the S3-1 data moves from 65° to 75° north geographic latitude during the period shown. Local time of the data is constant at about 11.5 hours. Geographic latitude and local time of the AE-C data varied from 65° south and 13.6 hours to 62° south and 10.5 hours.

On day 315 Kp increased from 3 to 5 to 7 on successive 3-hourly intervals (9-12, 12-15, and 15-18 hrs GMT) and remained high for 3 days. The density in both hemispheres increased by about 40% over pre-storm values following the Kp increase on day 315. In the northern hemisphere the increase over pre-storm density values is 38% at 16.6 hours and 39% at 22.8 hours. In the southern hemisphere there is a 41% increase observed at 20 hours. From the different times of available data it is not possible to determine whether there are hemispherical differences in the response of the atmosphere to this storm. The density variations appear to remain in phase for about 1½ days. Starting near day 317 a phase difference is observed between the north and south hemisphere data. The maxima are closely related to geomagnetic latitude, indicative of localized heating described by Jacchia, Slowey and von Zahn (1976). A complete study of the localized atmospheric response is not possible. The latitude of the data and its position with respect to the zone of maximum heating is not constant. A clearer picture of the latitudinal variation can emerge by extending the study to include data at other altitudes. The middle curve, showing the ratio of measured density to the Jacchia (1971) model illustrates that the phase and amplitude of geomagnetic storm response modeling is not presently in a good state.

Figure 2 shows composition data from each satellite for the period 8-15 Nov. (d. 312-319). The accelerometer density data are shown in the top curve for comparison. The middle and bottom give respectively the atomic oxygen and molecular nitrogen data. The AE-C OSS data are denoted by asterisks and the S3-1 MS data are denoted by squares. Since this time period had not previously been selected as a science investigation all the available OSS data had not been put into the unified abstract file. The data are available and can be used in future studies. The time

period has been extended to show the features of the composition measurements during relatively quiet conditions on 8 Nov. 74 (day 312). The Kp index was ≤ 3 from hour 0 to hour 18 on this day. A systematic difference between the northern and southern hemisphere composition is observed on day 312. The N_2 is higher in the summer hemisphere by about a factor of 1.6 while the O is higher in the winter hemisphere by about a factor of 2. These results are consistent with the seasonal variations reported by Mauersberger et al., (1976). An orbital correlation between the two instruments has not yet been made. However, at 160 km excellent agreement has been found between the mass densities deduced from (a) OSS and the accelerometer on AE-C (Marcos et al., 1976a) and (b) MS and the accelerometer on S3-1 (Marcos et al., 1976b).

Variations in the composition observed with the S3-1 MS experiment have been described for this storm period by Philbrick et al., (1975). The general behavior of atomic oxygen measured by OSS and MS is similar. There is a generally ambiguous response to geomagnetic activity with a trend to decrease during storm periods. The molecular nitrogen increases by a factor of two during the storm onset on day 315. This large N_2 increase at 160 km is not explained solely by a temperature increase. Additional mechanisms including convection and variation in the homopause height have been suggested.

Both sets of nitrogen measurements show a modulation associated with geomagnetic latitude as observed in the neutral density data. While immediate pre-storm N_2 data were not available from OSS for this study some different features can be seen in the northern and southern hemisphere data. For example on day 318 the northern hemisphere values are approximately equal to those of day 312 but the southern hemisphere data are

higher by about 50%. This could imply a seasonal variation in storm response. A mechanism for such behavior has been suggested by Prolls (1976). However, in view of the limited amount of data presented here and the localized nature of geomagnetic heating further studies are required to assess storm effects. For example as Champion (1976) has indicated Kp is an inadequate indicator of the relation between geomagnetic activity and atmospheric response. It is possible that during this storm the high Kp values were more indicative of northern hemisphere geomagnetic activity than of southern hemisphere behavior.

Acknowledgements. I am greatly indebted to Dr. C.R. Philbrick, AFGL, and Drs. W.E. Potter and D.C. Kayser for valuable discussions and their gracious efforts in making their data available for this study.

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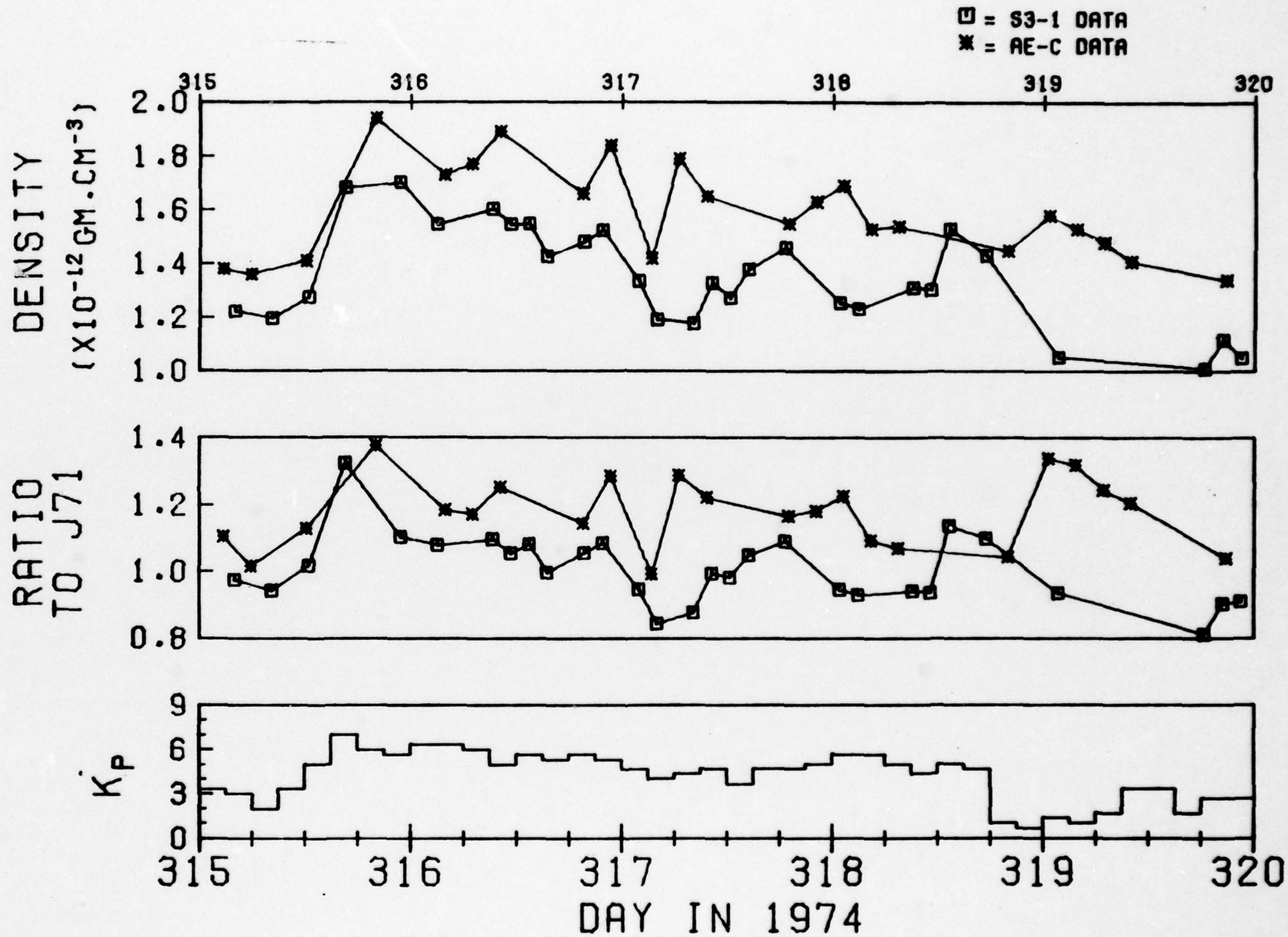
FIGURE 1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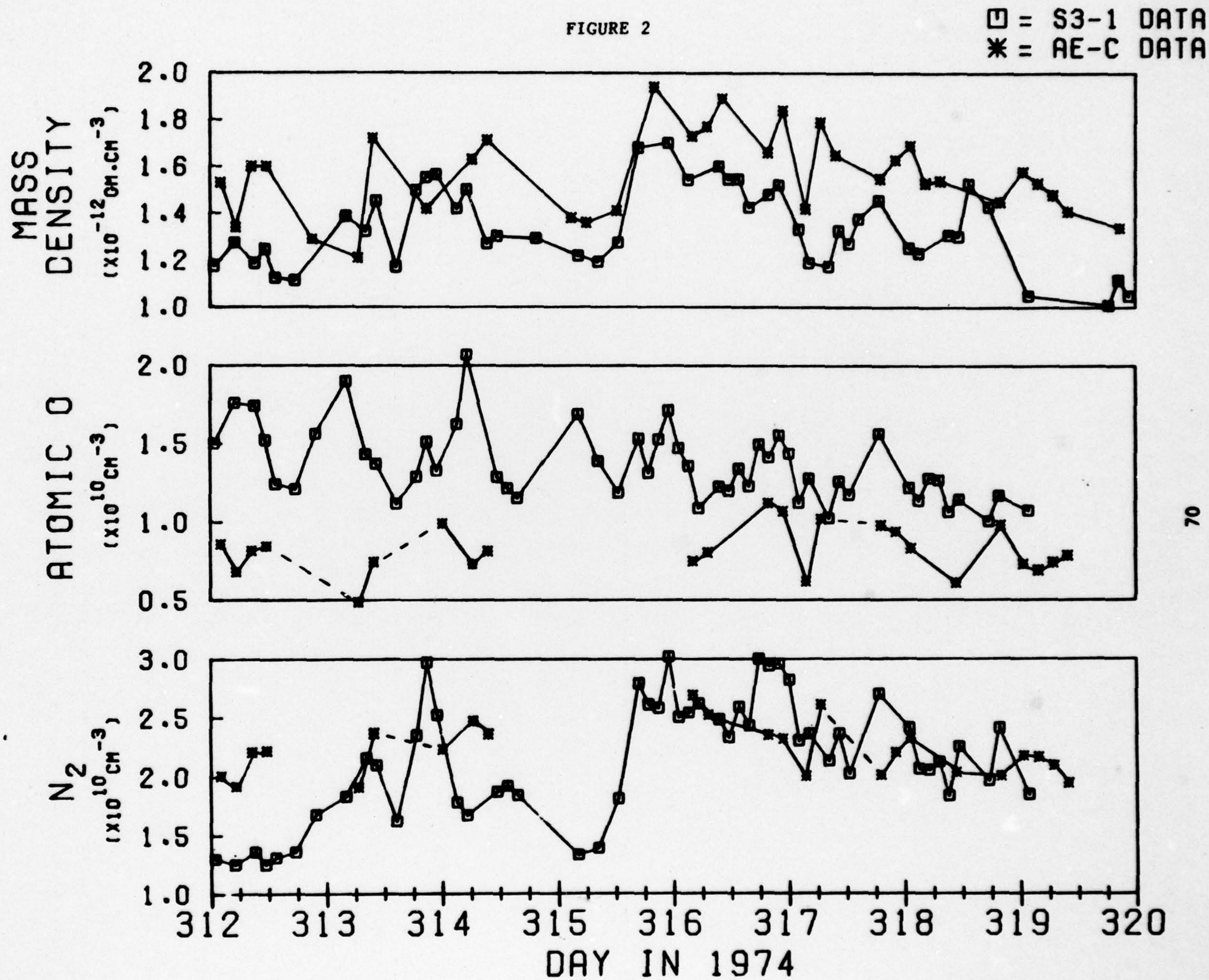
= AE-C DATA
DENSITY
(X10^{-12} GM.CM^{-3})
RATIO
TO J71
K_P
315
316
317
318
319
320
DAY IN 1974

FIGURE 2



□ = S3-1 DATA
✱ = AE-C DATA
MASS DENSITY
(X10^{-12} GM.CM^{-3})
2.0
1.8
1.6
1.4
1.2
1.0
ATOMIC O
(X10^{10} CM^{-3})
2.0
1.5
1.0
0.5
N$_2$
(X10^{10} CM^{-3})
3.0
2.5
2.0
1.5
1.0
312
313
314
315
316
317
318
319
320
DAY IN 1974